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L. O. HOWARD, Chief

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GIPSY MOTH TREE-BANDING MATERIAL: HOW TO MAKE, USE, AND APPLY IT.

By C. W. Collins, *Entomological Assistant*, and Clifford E. Hood, *Scientific Assistant, Gipsy Moth and Brown-tail Moth Investigations.*

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INTRODUCTION.

Previous to 1896 various materials, such as gas tar, coal tar, tree lime, raupenleim, bird lime, printers' ink, cotton batting, and some sticky substances, were used on tree trunks to bar wingless adult insects and caterpillars from ascending trees to deposit their eggs or feed upon the leaves. Since that time there have been developed and used in large quantities sticky compounds, some of which are of great merit. The better grades of this material were used extensively in control work against the gipsy moth (*Porthetria dispar* L.) from 1905 until about 1915, but since this time its use has been somewhat restricted owing to the high cost of the material and its application, and to the increase in high-power spraying.

Raupenleim, which is of a greasy nature, was first imported from Germany and experimented with in control work against the gipsy moth by the State Board of Agriculture of Massachusetts in 1892. Thirteen and one-half tons of the material were imported and used in banding 40,704 trees during that season and the next. The raupenleim used in 1892 was very effectual, but much of the importation of the following year was inferior in quality and the results obtained were not so gratifying. Further use was made of this material, however, in a more limited way by the Massachusetts Board of Agriculture until 1899. A further field test in barring gipsy moth caterpillars was given this material in 1909 from a sample which Dr. L. O. Howard, while in Europe, had shipped to the United States Bureau of Entomology at Boston, Mass. In 1912 Mr. L. H. Worthley, of this bureau, while making gipsy moth investigations in Europe, was impressed with the successful use of it abroad, and had a barrel of the material shipped to the bureau at Melrose Highlands, Mass. While the results from the former sample sent from Germany to the Bureau of Entomology did not meet the expectations of those testing it, general approval attended the results of the latter.

During the winter of 1915, Mr. A. F. Burgess, in charge of moth work for the Bureau of Entomology, sent samples of raupenleim to Dr. J. K. Haywood, chairman of the Federal Insecticide Board, Washington, D. C. These were turned over to Mr. C. C. McDonnell who arranged to have them analyzed and studied by Mr. E. L. Griffin, of the Insecticide Laboratory, with the idea of producing a like or similar compound. Several samples were made and sent to Melrose Highlands, Mass. These were tested and gave good results, consequently 4 tons of the material were made by the Insecticide Laboratory during the spring of 1916 and used in banding against the gipsy moth in New England during that season. The original formula and results secured during these experiments were published by Messrs. A. F. Burgess and E. L. Griffin.[1] Work by the writers in the preparation of this compound has resulted in certain changes in proportion and methods of mixing, which are described in the following pages. The product which gave the most satisfactory results is referred to under the name of "gipsy moth tree-banding material." The formula for making this product is on page 6.

USES OF GIPSY MOTH TREE-BANDING MATERIAL.

It has been the custom in the control work against the gipsy moth to band trees in heavy infestations along roadways, on lawns, and in dooryards where extensive migration of caterpillars is expected or where protection of valuable trees is especially desirable. Bands are now being used extensively at infestations in the border territory by Mr. H. L. McIntyre of this bureau, who has charge of the scouting and extermination work. The infestations considered dangerous in the outside territory are often located on isolated apple or oak trees and in open woodlands which are situated on slopes or elevations where the wind plays an important part in the dispersion of the small larvæ. Infested trees are also frequently located near or in the stone walls so common in New England, and eggs deposited in the stone walls are very difficult to find and to treat. Under such conditions bands are very effective in preventing newly hatched larvæ from crawling out of walls into trees that have been cleared of egg clusters, thus preventing also rapid and long-distance wind spread of the larvæ.

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[1] BURGESS, A. F., and GRIFFIN, E. L. A NEW TREE-BANDING MATERIAL FOR THE CONTROL OF THE GIPSY MOTH. *In* Journ. Econ. Ent., v. 10, no. 1, p. 131–134, pl. 6–7. February, 1917.

Bands were at one period used quite extensively in heavy infestations of the gipsy moth along roadsides where it was necessary to protect trees upon which the egg clusters had been treated against the ravages of migrating caterpillars from adjoining woodlands. This served to prevent caterpillars from ascending trees that have branches overhanging the road, from which they could spin down by means of silken threads, be caught by passing vehicles, and be dispersed by that means.

MAKING GIPSY MOTH TREE-BANDING MATERIAL.

MATERIALS USED.

A. Coal-tar neutral oil having a density of 1.12 to 1.15 at 20° C.
B. Hard coal-tar pitch, melting point about 49° C.
C. Rosin oil, known as first run " kidney," having a viscosity of 52 at 100° C. tested with a Saybolt universal viscosimeter.

A neutral or nearly neutral coal-tar oil must be used, as coal-tar acids are sometimes injurious to trees.

As the rosin oil is the result of crude distillation, the grade is not constant, varying in color, viscosity, and acidity. Some rosin oils are light to dark brown, some black, others dark blue, and some are possibly of other shades.

Some rosin oils contain more free acid than others, and usually those with the higher acid content give the best results. On the other hand, if too highly acid, the mixture saponifies so quickly that it becomes too thick before the last addition of coal-tar neutral oil is made, with the result that when the latter is added it will not mix properly, thus making a poor product.

The rosin oil that gave the best results was of a medium to dark brown color, having a viscosity of 52 at 20° C. tested with a Saybolt universal viscosimeter and containing 26 per cent free acid. This oil saponified in from 4 to 10 minutes; those which saponify rapidly are not so satisfactory to use.

In some cases where the free acid contents of the rosin oil are low, the mixture will saponify very slowly, and when fully saponified the finished product will be so soft that it will not stand up on the trees, even at moderate temperatures. In order to remedy this, it is necessary to add more rosin oil to bring the acid content up to the required amount, so that the product will set properly and remain intact on the trees during high summer temperatures. On the other hand if this method is used, and it requires very much rosin oil to bring about the proper saponification, the resultant product, which will have a larger percentage of rosin oil, is made tougher, and when placed on the trees will film over much more quickly.

Rosin oils low in viscosity but highly acid, though they set very quickly, will give a product which will not as a rule have body enough to stand up well at high temperatures, while rosin oils with a viscosity of 52 or higher contain about the right amount of acid to saponify the mixture thoroughly and make the resultant product of the right consistency to stand up and remain efficient at high temperatures.

D. Ordinary commercial hydrated lime.

This product, known as hydrated lime, is sold commercially and can be bought in 50-pound bags. If this can not be obtained ordinary rock or quick lime can be used, and this should be slaked with just enough water to make the resultant product a dry powder or hydrated lime. This should be passed through a sieve having 14 meshes to the inch. A coarser mesh should not be used.

EQUIPMENT USED.

The banding material was mixed in a 25-gallon soap kettle (fig. 1), which was equipped with a stirring arrangement, having double paddles turning in opposite directions. The mechanism used to turn the paddles in opposite directions was part of the rear end assembly of a light automobile. The axle shaft turned in one direction and a small length of iron pipe inclosing this shaft to about half way down from the top was so attached that it would turn in the opposite direction. To this axle and iron pipe, respectively, were attached double paddles so shaped that the material was kept moving in all directions, thereby making an even mixture. Two pairs of paddles, A and B, which were attached to the outer shaft, moved in one direction, and C and D, attached to the inner shaft, moved in the opposite direction. This was operated by a belt from the shafting of the machine room in the basement of the storehouse mentioned above. The speed of the machine was timed to allow the paddles to turn 30 revolutions per minute. The kettle used was provided with a steam jacket, but usually no heat was required. At low temperatures both the rosin oil and coal-tar neutral oil become rather thick, and do not mix well, consequently a small amount of heat is necessary to insure the proper mixture. Also, when the viscosity of the rosin oil is high, it is necessary to apply heat to the mixture in order to thin the rosin oil so that it will combine properly with the other ingredients. During hot weather it will usually mix well without the addition of heat. In most cases the materials, when being mixed, should be kept at temperatures ranging from 60° to 75° F.

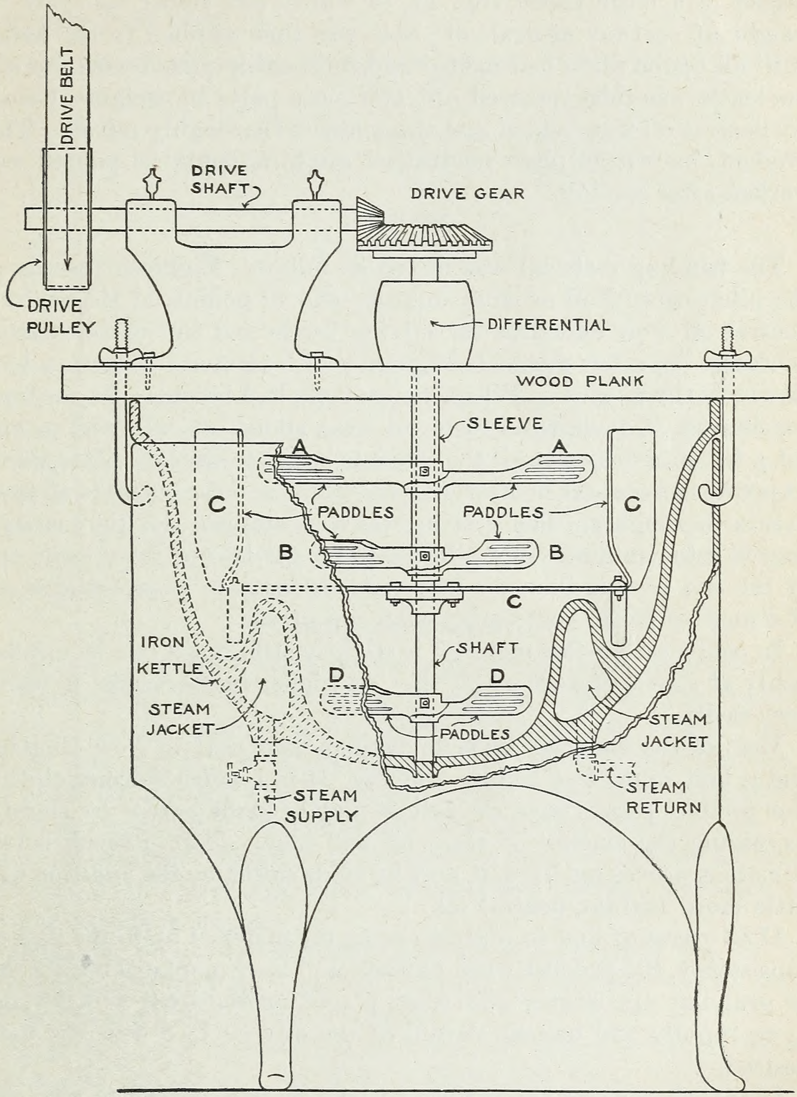


Fig. 1.—Sectional view of kettle or mixer of 25 gallons capacity showing detailed arrangement of transmission and paddles for use in preparing gipsy moth tree-banding material.

STOCK MIXTURE.

The gipsy moth tree-banding material was made in large quantities as follows: One part by weight of hard coal-tar pitch was placed in a large kettle (fig. 1), to which was added one part by weight of coal-tar neutral oil; heat was then applied to the kettle until all of the pitch had melted and thoroughly mixed with the oil; the kettle was then removed and two more parts by weight of coal-tar neutral oil were added and the contents thoroughly mixed. This product, known as pitch neutral-oil mixture, could be poured and worked after cooling.

FORMULA.

The banding material was mixed as follows: Eighteen pounds of the pitch neutral-oil or stock mixture and 70 pounds of the coal-tar neutral oil were added to the mixing kettle and the stirrer started working. In a few moments 12 pounds of hydrated lime were added slowly to the mixture. When the contents had become of a uniform consistency 50 pounds of rosin oil were added and allowed to mix for a few minutes, or until the contents began to thicken, after which 20 pounds of coal-tar neutral oil were added and the contents allowed to mix thoroughly. The stirring was then stopped and the material poured into containers and allowed to set for two or three days, and by the end of this time the material had set into a semisolid state, of somewhat softer consistency than cup grease.

In cold weather this material is slightly stiff, but it can be applied easily at a temperature of 35° F. At higher temperatures it works very easily.

Most of the material made so far has been used in New England and is best suited to a similar climate. If in a much warmer climate this product proves to be too soft, it may be made harder by slightly increasing the amount of rosin oil and lime. If in a much colder climate it proves too hard, it may be made softer by the addition of a little more coal-tar neutral oil.

If an excess of lime is added to bring the material up to the desired consistency, the product when finished will have more or less of a dry or granular appearance and when placed on the trees will dry out more rapidly and become devoid of the oily surface which is most desired.

If the viscosity of the rosin oil varies, it is necessary to alter the amount used. Figuring from the viscosity of the rosin oil used in this formula, which, as previously stated, is 52 at 100° C., tested with a Saybolt universal viscosimeter, a reduction of 4 pounds of the rosin oil should be made to every 15 points increase in viscosity.

When a reduction of the rosin oil is made, it is also necessary to make an addition of coal-tar neutral oil. Figuring from the amount used in the formula heretofore stated, which had a specific gravity of about 1.12 at 20° C., an addition of the neutral oil should be made to the amount first added and to the amount last added to the mixer, that is, an addition should be made for every 15 points rise in the viscosity of the rosin oil.

TABLE I.—*Method of adjusting formula to provide for difference in viscosity of rosin oil.*

Viscosity of rosin oil.	Weight of rosin oil.	Weight of coal-tar neutral oil, first addition to mixer.	Weight of coal-tar neutral oil, last addition to mixer.
	Lbs.	*Lbs.*	*Lbs.*
52	50	70	20
67	46	72	22
82	42	74	24
97	38	76	26

If the viscosity of the rosin oil falls between these numbers, the amount to be used should be adjusted proportionately, and the amount of coal-tar neutral oil to be used should also be adjusted accordingly.

When the viscosity of the rosin oil rises above 80 it becomes quite thick, and it is usually necessary, especially in cool weather, to apply heat to the mixing kettle in order to have it combine properly with the other ingredients. The amounts of pitch neutral oil mixture and lime to be added remain the same.

COST OF MATERIALS.

The cost of materials used (prices paid by the United States Bureau of Entomology in the fall of 1918) were as follows: The coal-tar neutral oil, 67¼ cents per gallon (about 7.1 cents per pound); rosin oil, 59 cents per gallon (about 7.09 cents per pound); the hard coal-tar pitch, $21 per ton (1.05 cents per pound). Based upon these figures the ingredients composing the tree-banding material cost 6.5 cents per pound. The labor in making the material figured 1.1 cents per pound, the total cost being 7.6 cents per pound. These prices do not include containers.

Metal containers are decidedly preferable to wooden (fig. 2) for storing or shipping the finished product, as the latter absorb some of the oil contained in the mixture.

Over 25 tons of this material had been made by the United States Bureau of Entomology, at Melrose Highlands, Mass., by December 31, 1919, and used in the gipsy moth work in New England.

APPLICATION OF THE BANDS.

PREPARING THE TREES.

In the application of sticky bands to forest and shade trees, the usual method is to scrape off, by means of a tree scraper, the loose scales of bark over a surface of 3 to 5 inches wide at the place the band is to be applied. In this procedure too much of the outer bark is often removed, or the inner layer is gouged in the operation, resulting in slight injury to the bark. It is very necessary preparatory to applying the sticky bands to secure a smooth surface. If not, the material, which sticks securely to the paddle used for applying, picks up much of the loose bark and in shaping the bands these particles are left on the surface and later form bridges for the caterpillars to cross. It is essential to scrape such bark as white oak, ash, or old apple trees both for the purpose of securing the desired smooth surface and to save material which would otherwise be wasted by working into the crevices. The sticky material is ordinarily applied by means of a paddle made of hard wood 2 to 2½ inches wide and with edge beveled obliquely for the convenience of the operator.

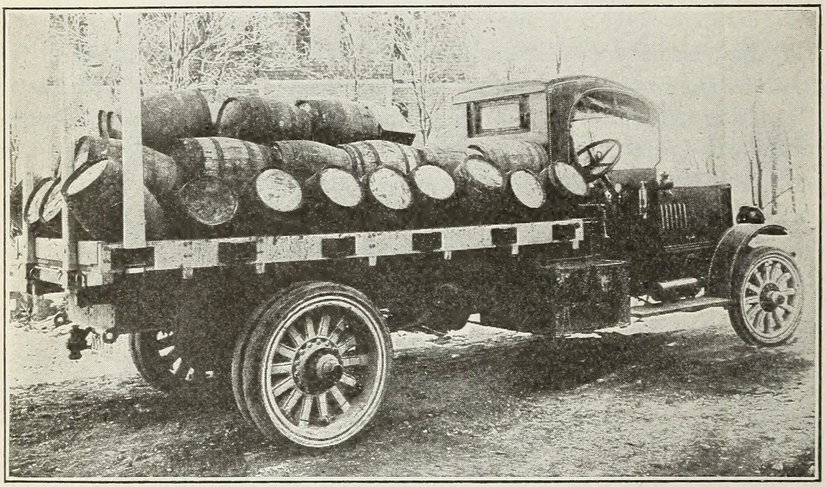
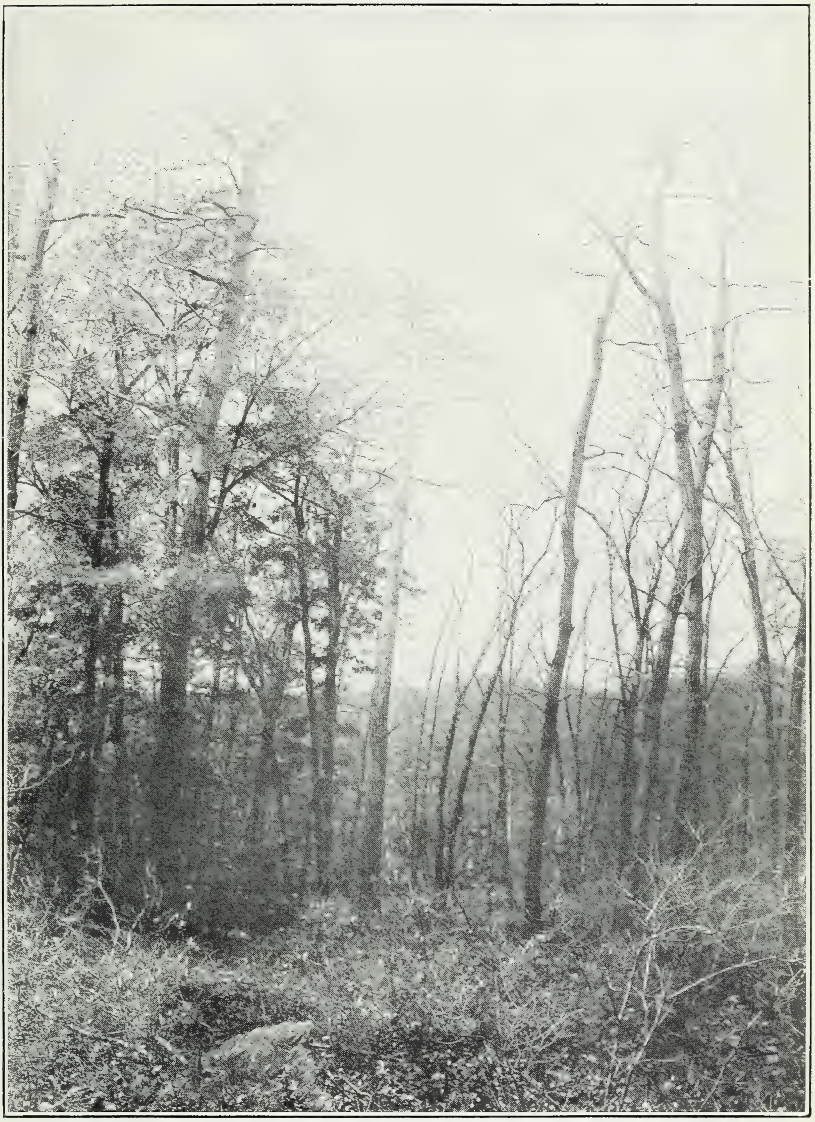


FIG. 2.—Truck containing 1½ tons of gipsy-moth tree-banding material, part of 25 tons made by United States Bureau of Entomology between 1917 and 1919.

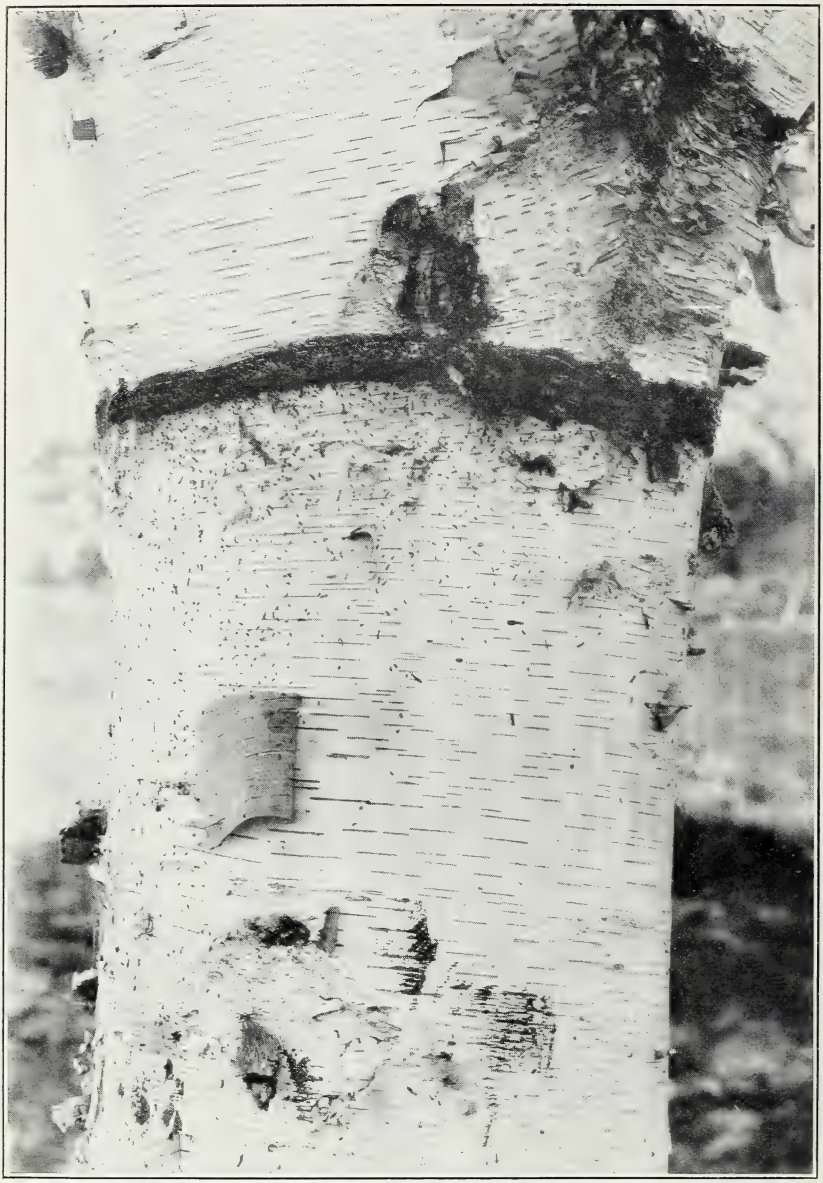
No scraping of the bark is necessary in applying gipsy moth tree-banding material unless such bark is very loose and scaly, as on an old white oak or apple, it only being necessary to rub the loose bark off with the hand.

The material is most economically and conveniently applied by means of a special gun (Pl. I). This consists of a tin cylinder 3 inches in diameter and 8 inches long, the lower end being closed except for a small opening over which the nozzle or molder is attached by means of solder. The gun is also provided with a removable plunger. After the material is put in it is forced through the nozzle by the plunger, which is manipulated by means of two handles. The handles work similarly to those of a pair of large shears (one being riveted stationary to the cylinder). The other



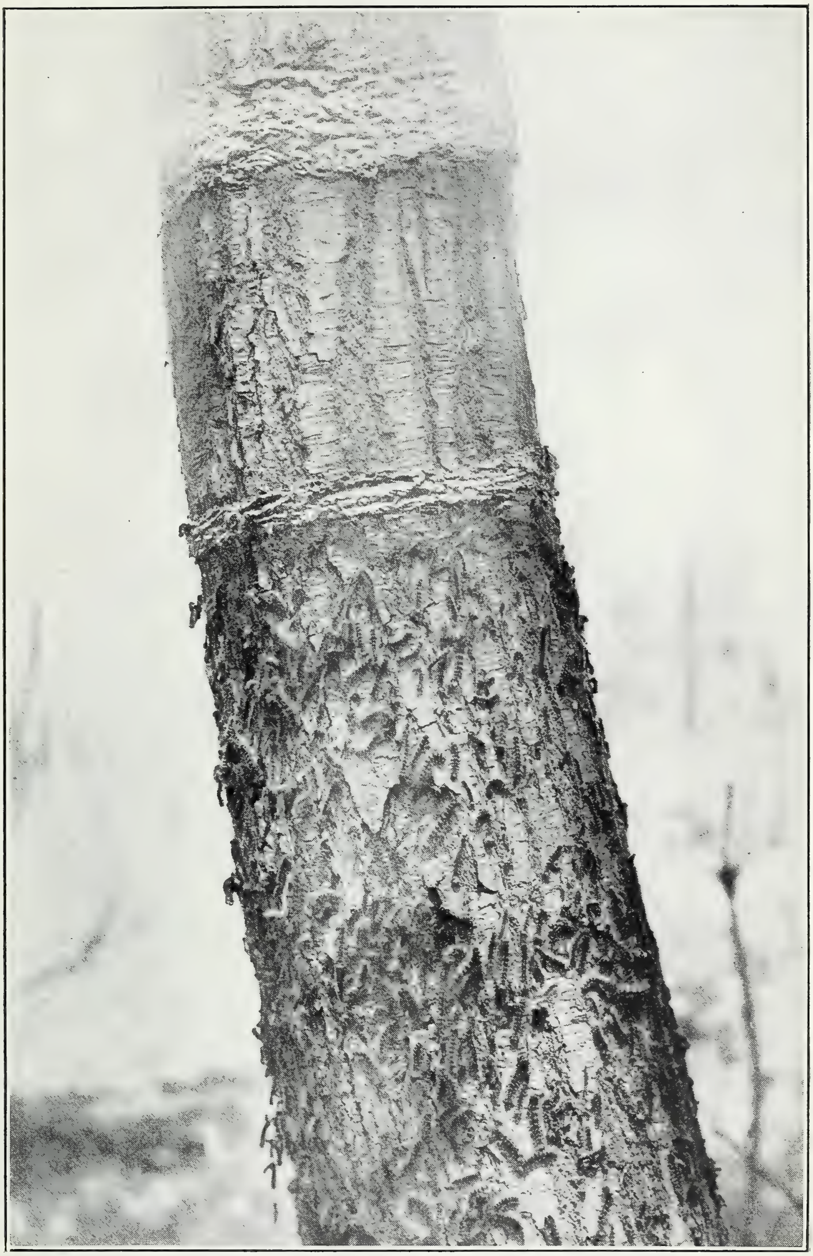
GIPSY MOTH TREE-BANDING MATERIAL

Woodland trees badly infested by the gipsy moth, 1919. No spraying or treating egg clusters by hand. Trees on right not banded, those on left banded with gipsy moth tree-banding material and saved from defoliation.



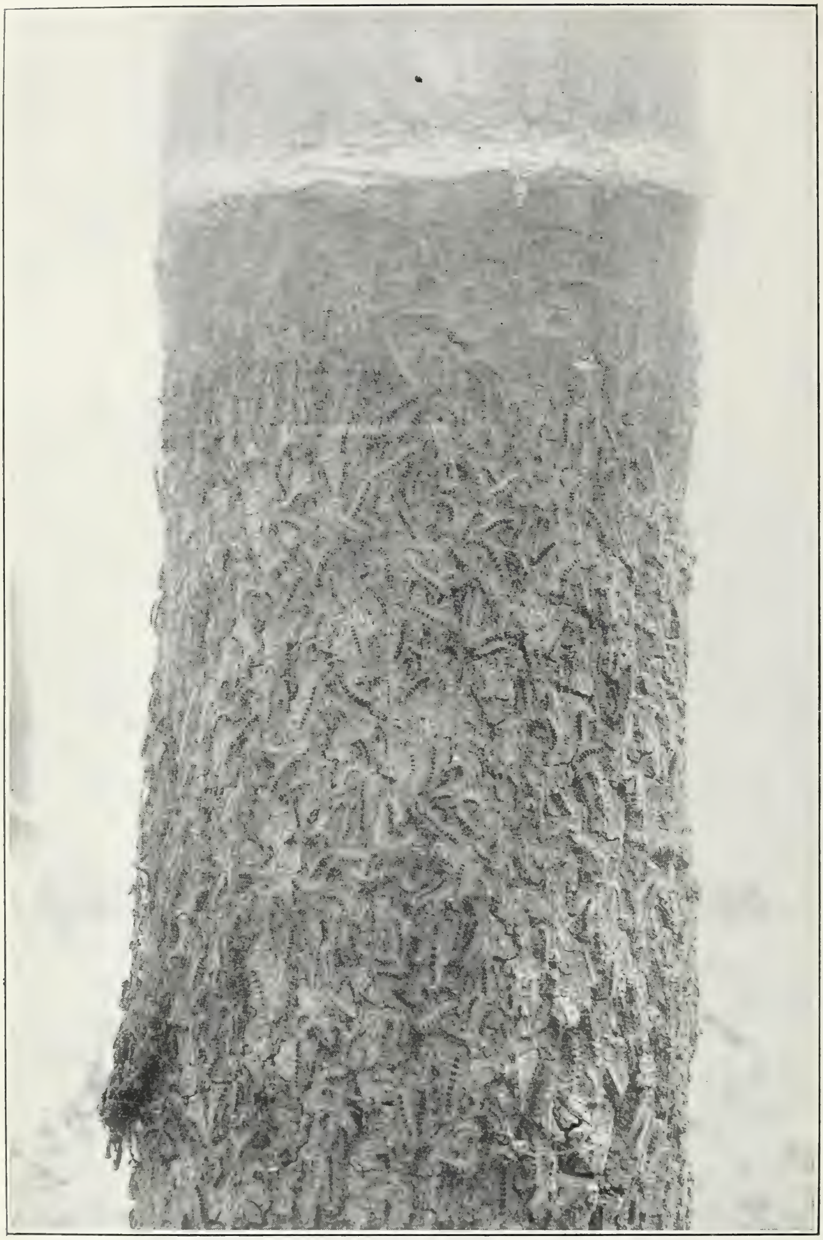
GIPSY MOTH TREE-BANDING MATERIAL

Showing band $\frac{13}{16}$ by $\frac{7}{32}$ inch barring small gipsy-moth caterpillars on white birch. Many small larvæ are embedded and dead in lower edge of this band.



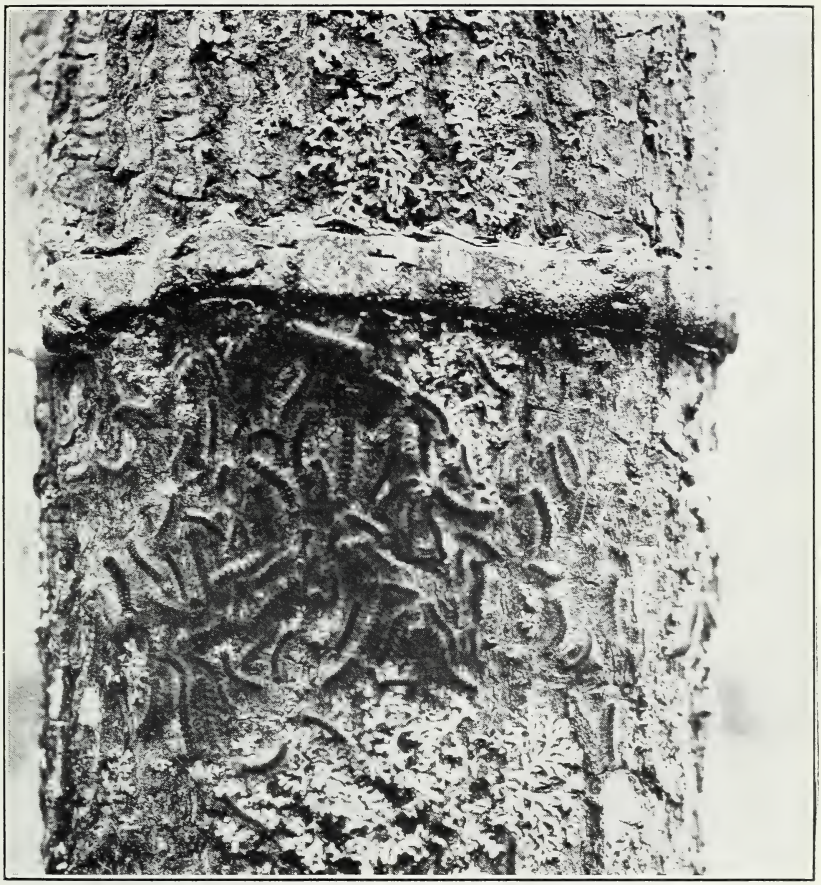
GIPSY MOTH TREE-BANDING MATERIAL

Narrow band has been re-treated by working over surface with putty knife. Check band above of sticky material with space free from caterpillars between, indicating efficiency of lower band. Note active caterpillars ascending to bands, then spinning down.



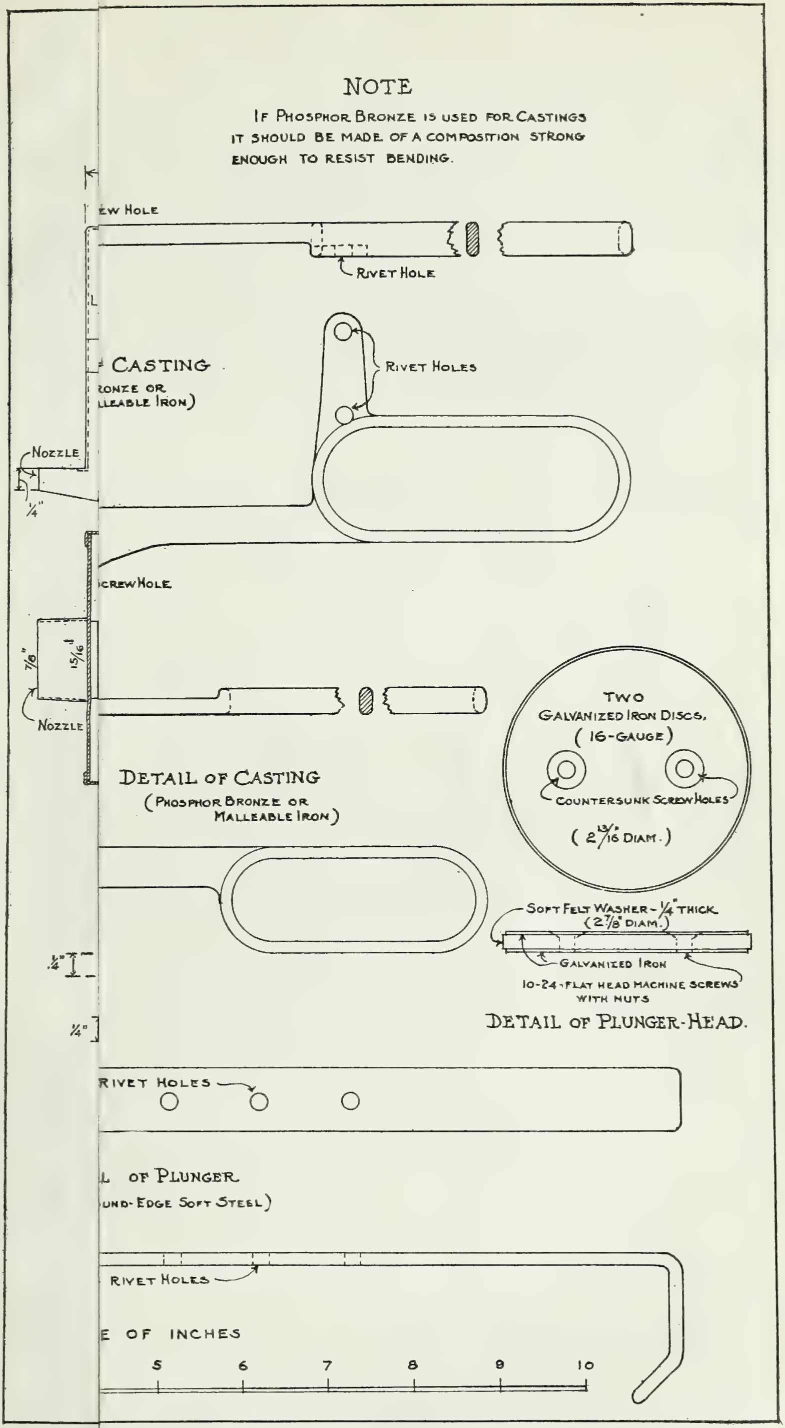
GIPSY MOTH TREE-BANDING MATERIAL

About 1,500 gipsy moth caterpillars estimated to be on lower part of trunk of this tree and barred by gipsy moth tree-banding material. This band was attended and kept in good condition because of the heavy infestation.



GIPSY MOTH TREE-BANDING MATERIAL

Narrow band without treatment barring half-grown gipsy moth caterpillars efficiently in a moderate infestation.



NOTE

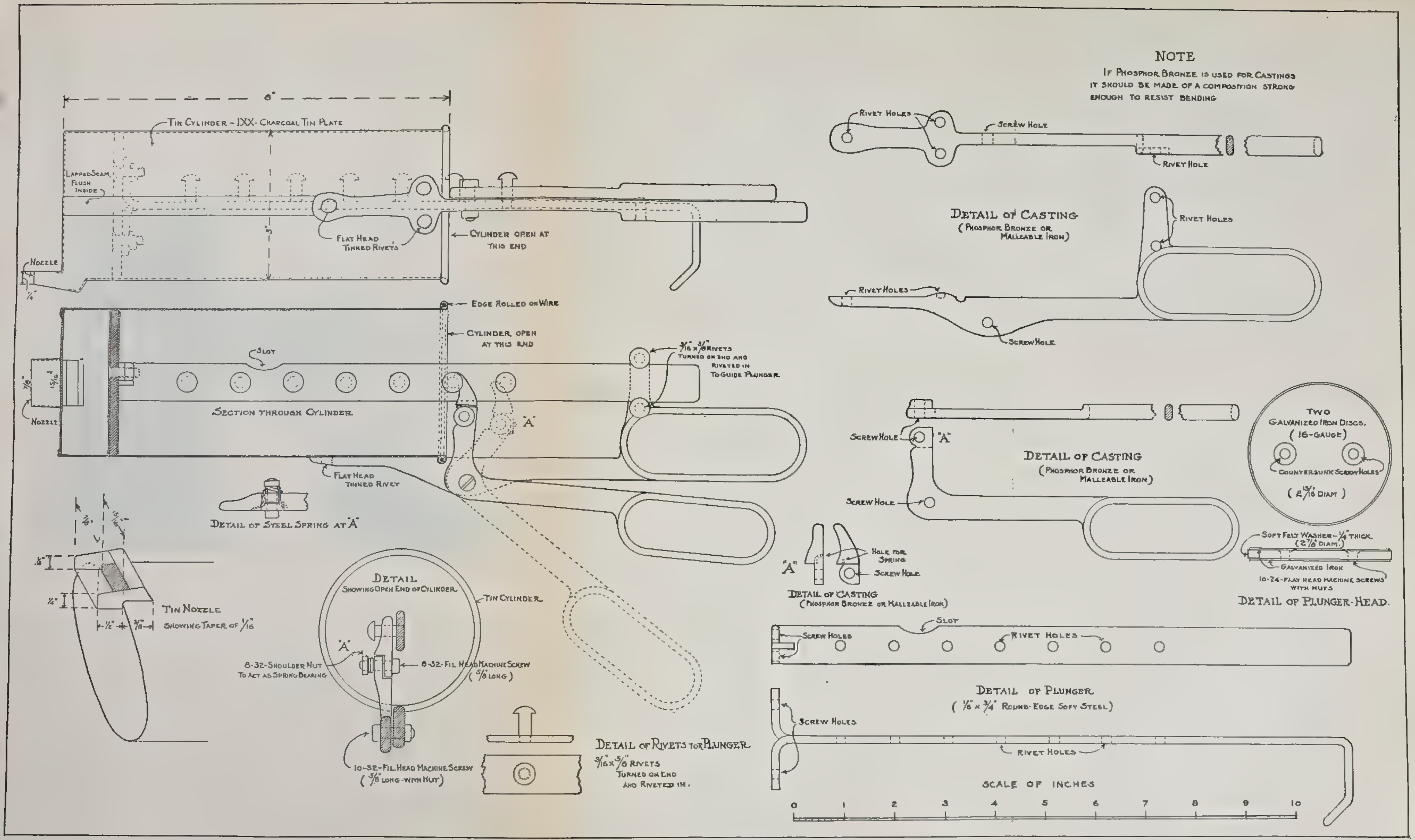
IF PHOSPHOR BRONZE IS USED FOR CASTINGS IT SHOULD BE MADE OF A COMPOSITION STRONG ENOUGH TO RESIST BENDING.

CASTING
RONZE OR
LLEABLE IRON)

DETAIL OF CASTING
(PHOSPHOR BRONZE OR MALLEABLE IRON)

DETAIL OF PLUNGER-HEAD.

L OF PLUNGER
UND-EDGE SOFT STEEL)


NOTE
IF PHOSPHOR BRONZE IS USED FOR CASTINGS IT SHOULD BE MADE OF A COMPOSITION STRONG ENOUGH TO RESIST BENDING
8"
TIN CYLINDER - IXX- CHARCOAL TIN PLATE
LAPPED SEAM, FLUSH INSIDE
3"
NOZZLE
1/4"
FLAT HEAD TINNED RIVETS
CYLINDER OPEN AT THIS END
EDGE ROLLED ON WIRE
CYLINDER OPEN AT THIS END
SLOT
7/8"
15/16"
NOZZLE
SECTION THROUGH CYLINDER
3/16" x 3/8" RIVETS TURNED ON END AND RIVETED IN TO GUIDE PLUNGER
"A"
FLAT HEAD TINNED RIVET
DETAIL OF STEEL SPRING AT "A"
1/8"
15/16"
1/4"
1/4"
1/2"
3/8"
TIN NOZZLE SHOWING TAPER OF 1/16
DETAIL SHOWING OPEN END OF CYLINDER
TIN CYLINDER
"A"
8-32-SHOULDER NUT TO ACT AS SPRING BEARING
8-32-FIL. HEAD MACHINE SCREW (5/8 LONG)
10-32-FIL. HEAD MACHINE SCREW (5/8" LONG - WITH NUT)
DETAIL OF RIVETS FOR PLUNGER
5/16" x 5/8" RIVETS TURNED ON END AND RIVETED IN.
RIVET HOLES
SCREW HOLE
RIVET HOLE
DETAIL OF CASTING (PHOSPHOR BRONZE OR MALLEABLE IRON)
RIVET HOLES
RIVET HOLES
SCREW HOLE
SCREW HOLE
"A"
DETAIL OF CASTING (PHOSPHOR BRONZE OR MALLEABLE IRON)
SCREW HOLE
TWO GALVANIZED IRON DISCS. (16-GAUGE)
COUNTERSUNK SCREW HOLES
(2 13/16 DIAM)
SOFT FELT WASHER - 1/4" THICK. (2 7/8" DIAM.)
GALVANIZED IRON
10-24-FLAT HEAD MACHINE SCREWS WITH NUTS
DETAIL OF PLUNGER-HEAD.
"A"
HOLE FOR SPRING
SCREW HOLE
DETAIL OF CASTING (PHOSPHOR BRONZE OR MALLEABLE IRON)
SLOT
SCREW HOLES
RIVET HOLES
DETAIL OF PLUNGER (1/8" x 3/4" ROUND-EDGE SOFT STEEL)
SCREW HOLES
RIVET HOLES
SCALE OF INCHES
0
1
2
3
4
5
6
7
8
9
10

GIPSY MOTH TREE-BANDING MATERIAL

Detail of tree-banding gun with dimensions and metals used. A gun made according to this detail applies a band 11/16 by 1/16 inch.

handle is provided with a ratchet at the end, which meshes with dogs on the guide of the plunger. The nozzle, which is also made of tin, is attached to the base of the cylinder and measures 1 inch long over all, projecting $\frac{9}{16}$ inch beyond bottom of cylinder. It is $\frac{3}{8}$ inch in depth at the bottom of the cylinder, tapering to $\frac{1}{4}$ inch at the tip, the space between these measurements being open on one side and end. The width is $\frac{7}{8}$ inch. A nozzle of these dimensions molds a band $\frac{13}{16}$ by $\frac{7}{32}$ inch.

The gun when filled holds from 1.6 to 2 pounds of the material. The material is easily transferred to the gun by means of a wooden paddle, or better by an implement made of thin steel plate 2½ inches wide and 10 inches long. The plate should be cut down so that a handle 4 inches long is provided at one end.

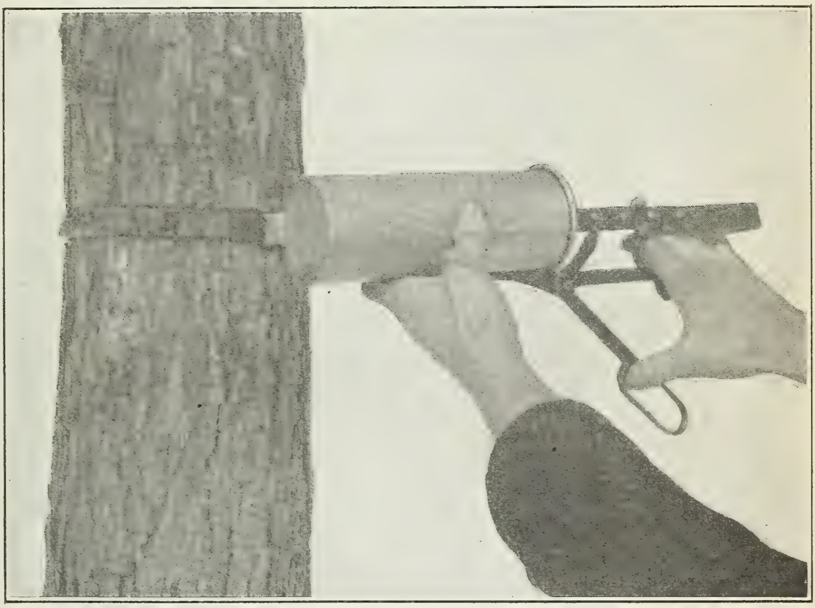


FIG. 3.—Tree-banding gun in position during application of band of gipsy moth tree-banding material. Note the square edges of this band.

The bands should be applied (fig. 3) to the trunks of trees 5 to 8 feet above the ground when the infestation of caterpillars is on private estates where there is danger of animals, such as horses or cows, rubbing into them. In the border territory of the gipsy-moth area where extermination of colonies is intended it is sometimes more advantageous to place the bands low down on the trunks of trees. This is done to prevent the small larvæ crawling up from the ground and clustering on the trunks of the trees in positions from which they may be more easily dislodged and dispersed by the wind.

It might be added that in some cases men applying gipsy moth tree-banding material have received temporary injury to the face and hands, particularly the latter. In such cases the operator experienced a burning followed by soreness similar to that of sunburn, the skin later peeling off to some extent. Not more than 50 per cent of the men using the material experienced any difficulty in this respect. It is possible that injury to those susceptible might be prevented by coating the skin with vaseline immediately before using the banding material.

SIZES AND SHAPES OF BANDS USED.

Experiments have been conducted in the field to determine what size, shape, and thickness of bands are most efficient (fig. 4). A gun, used in molding bands on the trees, was so arranged that nozzles of various sizes could be attached to it. Bands rectangular in shape, varying from $\frac{7}{8}$ to $2\frac{1}{2}$ inches in width were tested, and some having a thickness of $\frac{1}{16}$ inch at top, $\frac{1}{4}$ inch at bottom, and $1\frac{3}{16}$ inches broad; others $\frac{1}{16}$ inch at top and bottom and $\frac{5}{16}$ inch in middle, 1 inch wide; also some $\frac{1}{32}$ inch at top, $\frac{5}{16}$ inch near bottom, with rounded surface on lower edge, and a type having a thickness at top and bottom of $\frac{1}{4}$ inch, sloping to a thin smear in the middle and $1\frac{5}{16}$ inches wide.

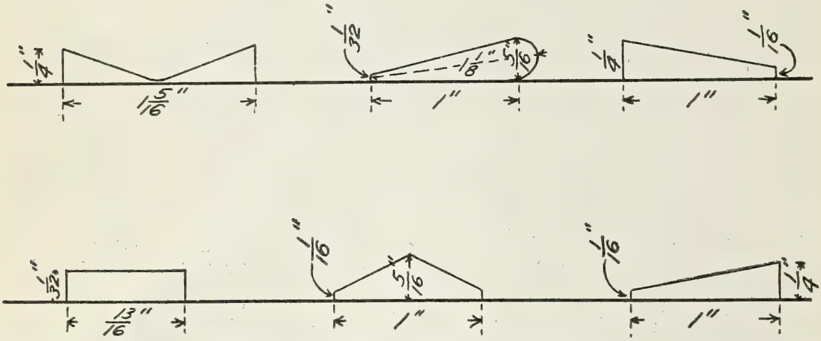


FIG. 4.—Showing some of the forms of bands of gipsy moth tree-banding material with which experiments were made. The rectangular form proved most successful.

The rectangular bands $\frac{13}{16}$ inch broad and $\frac{7}{32}$ inch thick proved both economical and efficient where the infestation of caterpillars was not too severe. Bands of this size have been used on a large scale in the extermination work against the gipsy moth in the border territory, and were found to be the most satisfactory under average conditions. Bands of these dimensions are very efficient when attended once or twice weekly during the active caterpillar season—the surface refreshened, the bridges removed, and the caterpillars beneath killed. The frequency with which the bands should be attended depends upon the degree of infestation, and too much stress can not be laid on the care of the bands during the caterpillar season. The mere presence of the bands, regardless of their condition, will not be effective in barring caterpillars. On the other hand, if regular and frequent care can not be given the bands during the heavy caterpillar season, it is sometimes advisable to use broader bands of $1\frac{1}{4}$ or more inches wide. Also double bands, each $\frac{13}{16}$ by $\frac{7}{32}$ inch, which can be applied with the regulation tree-banding gun by merely encircling the tree twice, are very effective where the infestation is extremely heavy. Bands should not be applied of more than $\frac{1}{4}$ inch thickness, as the weight of the material causes the bands to separate and slide down, especially on smooth-bark trees, unless such bands are $1\frac{1}{2}$ inches or more in breadth.

COMPARISON OF COSTS AND TIME REQUIRED TO SCRAPE TREES AND APPLY STICKY BANDS TO THAT OF GIPSY MOTH TREE-BANDING MATERIAL.

A comparative test was made in applying 25 pounds each of sticky banding material and the gipsy moth tree-banding material. A band of each kind of material was applied to the same trees, namely, shagbark hickory, white oak, black oak, red maple, and white pine. Each tree was calipered so that the linear feet of bands applied could be figured.

The sticky material banded 212 trees with an average diameter of 7.5 inches. These were applied with a 2-inch wooden paddle and were about $2\frac{3}{4}$ inches wide and $\frac{1}{8}$ inch thick. One hour and 42 minutes were required to scrape the trees and 3 hours and 54 minutes to band them, making a total of 5 hours and 36 minutes. Four hundred and nineteen linear feet of bands were applied out of 25 pounds of this material.

Twenty-five pounds of the gipsy moth tree-banding material were then applied with the gun, which molded a band $\frac{13}{16}$ inch wide and $\frac{7}{32}$ inch thick. One hundred and forty-five trees averaging 7 inches in diameter were banded. An average of 1.63 pounds was put in the gun each time it was filled. Fifty minutes were consumed in filling the gun and 90 minutes in applying the bands, or a total of 2 hours and 20 minutes. Two hundred and sixty-three linear feet of bands were applied with the 25 pounds. No extra time was required or allowed for preparing the trees previous to banding, as only a quick rub with the hand is necessary on trees where the bark is loose and scaly.

The prices of materials and labor in 1918 were as follows: Sticky banding material in large lots, 34 cents per pound; gipsy moth tree-banding material, 7.6 cents per pound; and labor for applying, 40 cents per hour. Comparisons on this scale per linear foot after bands had been applied were as shown in Table II.

TABLE II.—*Costs of gipsy moth tree-banding material together with application, 1918.*

	Price per pound.	Width and thickness of bands.	Cost of material and application per linear foot.
	Cents.	*Inches.*	*Cents.*
Sticky material	34	$2\frac{3}{4}$ by $\frac{1}{8}$	2.56
Gipsy moth tree-banding material	7.6	$\frac{13}{16}$ by $\frac{7}{32}$	1.08
Gipsy moth tree-banding material	7.6	$1\frac{1}{4}$ by $\frac{5}{32}$	1.19
Gipsy moth tree-banding material	7.6	$1\frac{1}{4}$ by $\frac{6}{32}$	1.42

It will be noted from Table II that with two samples of bands the cost of material plus the price of application of the gipsy moth tree-banding material is slightly less than one-half, while with another sample it is slightly more than one-half of the cost of the sticky material. This feature coupled with its efficiency in barring many species of caterpillars from ascending trees warrants its adoption where other conditions are favorable.

VALUE OF BANDING TREES IN WOODLANDS, ALONG FENCES, OR NEAR STONE WALLS.

When open woodlands or those that can be cleared of small growth and underbrush become badly infested with the gipsy moth it is sometimes practicable to save the trees by applying creosote to the egg clusters and subsequently banding the trees with gipsy moth tree-banding material (Pl. II). In treating the egg clusters by hand methods in such infestations, there are usually a varying number overlooked that were deposited on stones or trash on the ground. The larvæ that hatch from such egg clusters are prevented from ascending the trees by the bands, and numerous larvæ that are constantly spinning threads and dropping from foliage above are barred from reascending. The bands are effective against the small larvæ that lodge in trees as a result of wind spread only when such larvæ later spin down or drop to the ground.

Sections of woodlands not too heavily infested with the gipsy moth can sometimes be saved from defoliation by applying bands of this material and keeping them in good condition throughout the caterpillar season (Pl. II). If the infestation in woodland to be dealt with is severe, it is advisable to apply creosote to all egg clusters that can be reached and subsequently to band with gipsy moth tree-banding material.

Trees located along roadsides or near stone walls after once being cleaned of egg clusters may well be banded to prevent migrating larvæ that come out of walls or low brush from finding their way to the foliage (Pl. III).

PRACTICABILITY OF TREATING GIPSY MOTH EGG CLUSTERS AND OF BANDING TREES VS. POWER SPRAYING.

If a wooded area badly infested with the gipsy moth can be sprayed under proper weather conditions during the early feeding periods of the small larvæ, the results are usually very satisfactory. On the other hand, if there is a lack of power-spraying outfits in the vicinity or the work is slowed up by weather conditions until three-fourths or more of the foliage of the trees has been consumed, it is then evident that other methods should have been resorted to earlier in the season. Woodland spraying in 1916 cost about $5.50 per acre where large areas were involved.[2] It is estimated that the cost per acre in 1918 was $10.25, owing to increased cost of materials and labor. A further increase occurred in 1919.

The cost of banding an acre of woodland trees free from underbrush with gipsy moth tree-banding material in 1918 was $5.29. There were 269 trees per acre averaging 7 inches in diameter. The estimated cost of treating the egg clusters on these trees in 1918, provided the infestation was of a medium degree, is $8, making a total of $13.29 for treating and banding.

Spraying in 1918, in a wood lot that had been thinned, cost $3.04 less per acre. There are many factors to consider with the two methods of controlling infestations of the gipsy moth; for instance, spraying, to be effective, must be done within one month (about June); treating of egg clusters may be done between August and April, inclusive (nine months); and banding may be done during two or three months in the late winter and early spring. No definite recommendations can be given for localities and conditions in general, and these figures are merely to assist one in deciding upon a course of procedure that best suits the particular conditions.

RESURFACING OLD BANDS OF GIPSY MOTH TREE-BANDING MATERIAL.

Several experiments have been conducted to obtain data on the best method of resurfacing bands one or more years old (Pl. IV). Turpentine, coal-tar neutral oil, and kerosene have been applied with a brush to old bands in the early spring. These oils tend to dissolve the hardened surface, but the effect lasts only about one month or less. New gipsy moth tree-banding material was dissolved in these oils and the mixture painted on the surface with slightly more lasting results than in the case of the former method. The latter method was made more efficient by the use of a putty knife or small wire sink brush (Pl. V), which thoroughly stirred up the surface of the old bands to one-half their depth. Another efficient method was to use the putty knife alone, and with it thoroughly work up and renew the old surface.

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[2] WORTHLEY, L. H. SOLID STREAM SPRAYING AGAINST THE GIPSY MOTH AND THE BROWN-TAIL MOTH IN NEW ENGLAND. U. S. Dept. Agr. Bul. 480. 1917.

After bands have remained on trees for one or more years it is often advisable to resurface with the special gun. The bands shrink in dimensions after being applied more than a year so that a nozzle of the same size as was originally used fits over them, thereby applying a thin smear of the material to all exposed sides. One pound of the material will resurface from 25 to 30 linear feet against 10.5 at first application when a nozzle $\frac{7}{8}$ by $\frac{1}{4}$ inch is used in each case. This is the most efficient method of resurfacing known and leaves the bands in practically the same condition as when they were first applied.

BEHAVIOR OF CATERPILLARS BENEATH GIPSY MOTH TREE-BANDING MATERIAL AND ITS EFFECT UPON THOSE CROSSING BANDS.

The first samples of gipsy moth tree-banding material were tested in 1915. At that time the consistency of the material was quite stiff and caterpillars frequently crossed the bands in areas that had partly dried or filmed over on the surface. The idea as conveyed by the Germans in 1912, when a quantity of raupenleim was imported for experimental purposes, was that the nun moth (*Lymantria monacha* L.) and the gipsy moth (*Porthetria dispar* L.) were barred beneath the bands from their dislike of the tar odor emitted by the compound. Some experimenting and many observations have been made to ascertain if the guiding sense in preventing caterpillars crossing bands was smell or touch. Rather hard and soft mixtures with varying degrees of odors and substitutions for the coal-tar odor have been made with pine tar and other ingredients. Whenever the material was quite stiff, regardless of the odor, the caterpillars frequently crossed or rested on or near the bands (Pl. VI). Gipsy-moth caterpillars were seen repeatedly to go up to bands and touch them either with the head pencils of hairs or mouth parts, or walk into them. If the surface of the bands was soft, oily, greasy, or sticky, affording discomfort to the touch or making it impossible to secure a footing, the caterpillars usually turned back. As many as 97 to 99 per cent of the caterpillars in a heavy infestation were barred on some trees by the soft, oily, gipsy moth tree-banding material used in 1919 (Pls. IV, V).

Many caterpillars, especially the younger stages of the gipsy moth, in attempting to cross or when blown into the bands by the wind, quickly die from the effects of the material covering the ventral portion of the body and entering the spiracles. The percentage of larvæ killed in this manner is very high. There were from 150 to 200 small caterpillars dead in the oily surface of each of a few bands in a heavy infestation in 1919 with from 1,500 to 2,000 barred by the same bands. Large larvæ of several species are also killed from effects of the material penetrating the body and spiracles of those venturing into the bands.

EFFECT ON BARK OF TREES.

Several experiments have been conducted since 1915 to determine the extent of injury, if any, to the bark of forest, shade, and fruit trees that were banded. Trees were selected with rough and smooth bark, as also peach and apple trees of various ages. In no case was material injury done to the bark with the gipsy moth tree-banding material, the bands being 1 to 2 inches wide. The oil of the bands sometimes penetrates $\frac{1}{32}$ to $\frac{3}{32}$ inch deep on rough-bark trees. Wherever slight surface injury was noted from the penetration of oils, new cells formed in the cambium layer, which gave the bark a slightly swollen appearance at that point. Such slight local injury did not affect the growth or vigor of the trees, or the production of fruit in the case of bearing fruit trees.

Bands 6 to 10 inches wide were placed on peach trees aged from 1 to 15 years. These were applied at the base partly beneath the surface of the soil with the idea of noting injury to the tree should this material prove effective in preventing egg deposition of the peach-tree borer (*Sanninoidea exitiosa* Say). No material injury was noted to the bark save the slight local killing of cells in the outer bark, as was cited above with the forest and fruit trees. This was overcome by the growth of new cells in the cambium layer of the bark. The vigor and fruiting of the trees were not impaired so far as could be detected.

VALUE OF BANDING APPLE TREES LOCATED NEAR WOODLAND INFESTED BY THE GIPSY MOTH.

Many apple orchards or scattering apple trees in New England are located near or bordering on woodland infested with the gipsy moth. After the egg clusters on such trees have been treated with creosote a reinfestation the same season sufficient to damage or defoliate the trees badly often occurs. This condition is brought about by wind-spread of newly hatched caterpillars and the migration into the trees of small larvæ that hatched in near-by hidden places and of larger caterpillars which crawl from the woodlands. This condition can be relieved by spraying with arsenate of lead just after the caterpillars have hatched and once or oftener during the active feeding season. The owner of a small number of apple trees does not usually possess a spraying outfit that will cover large apple trees thoroughly and he is obliged to depend upon the local town power sprayer or private jobber for this work. The operators of such sprayers always have a large amount of work to do with the equipment at hand, consequently many orchards are sprayed late in the season after caterpillars have almost defoliated them, or they are not sprayed at all.

This condition may be greatly relieved by the application of bands of gipsy moth tree-banding material (Pl. VII). If apple trees are located from 50 to 400 feet or more from a badly infested woodland they are liable to severe reinfestation early in the season. If spraying can not be done it has been suggested that relief might be had by shaking the half-grown caterpillars from the trees that have little or no fruit by the use of a long pole to one end of which an iron hook is bolted. If this is done, the upper limbs should be shaken first followed by those beneath. The caterpillars removed in this manner will be prevented from reascending the trees by the bands and may be killed beneath them.

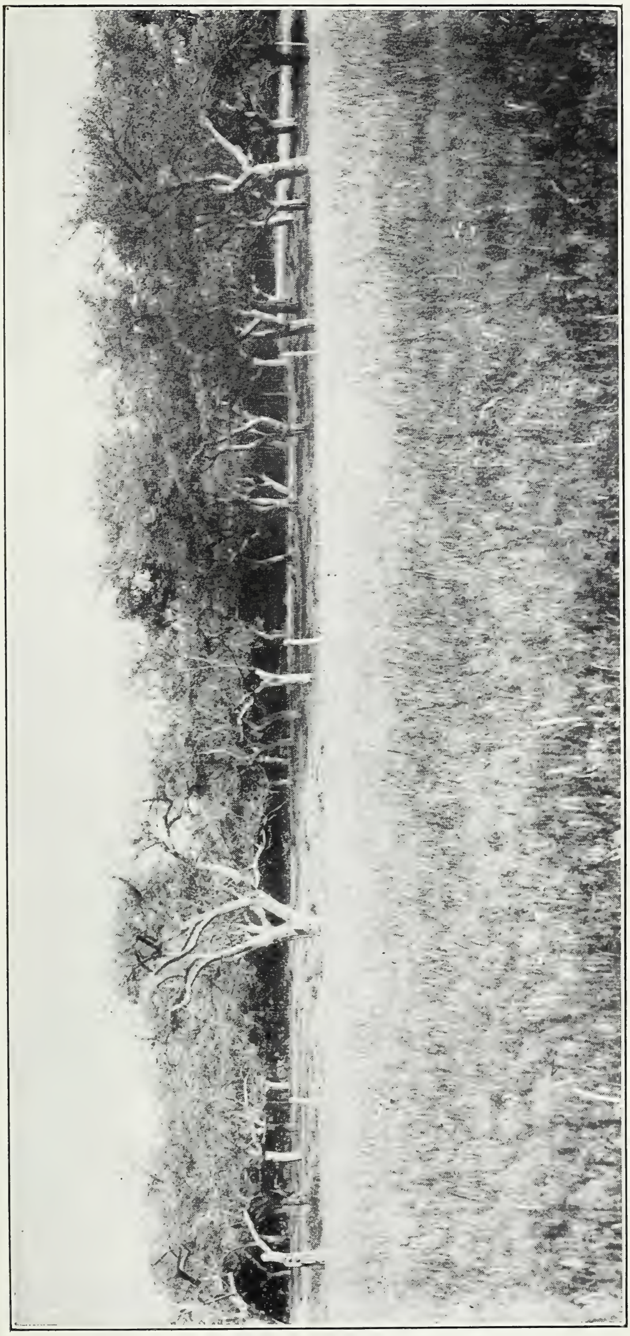
Banding of apple trees is also sometimes advisable together with spraying if the trees are located in an especially dangerous position with regard to infestation. All cavities should be tinned or cemented before bands are applied. It is usually advisable to apply spray instead of bands to very young apple trees 8 years old or less, as such trees can be readily sprayed with any hand outfit.

SPECIES OF INSECTS AGAINST WHICH GIPSY MOTH TREE-BANDING MATERIAL IS EFFECTIVE.

Experiments have been conducted in the laboratory and in the field with several species of insects for information as to which native species of larvæ and adults this material might be effective in barring. Through cooperation the material was tried in Nova Scotia against adults of the fall cankerworm (*Alsophila pometaria* Harr.) by Prof. W. H. Brittain, who reports rather unfavorable results in barring that species. He states that where the infestation was not too heavy the bands worked fairly well, but where the moths appeared in enormous numbers, as was frequently the case, bands 6 inches wide were bridged and crossed in a very short time. It is apparent that for the fall cankerworm the formula used for spring and summer banding against the gipsy moth should be modified so that it will remain soft during fall temperatures, at the time the cankerworms are active, and thus be more effective.

Dr. A. L. Quaintance, of the Bureau of Entomology, had some of the material tested on peach trees at Vienna, Va., against the peach-tree borer (*Sanninoidea exitiosa* Say). He states that while "no injury or ill effects to the trees could be noted after one year, it was only moderately successful in controlling the insect." The material was also tried in New Jersey on peach trees against the above insect by Mr. Alvah Peterson, who applied the bands 4 to 8 inches wide at the base of trees 10 years old or more. He reports that "when the trees were wormed during the fall of 1919 the check trees showed a total of 39 larvæ ($\frac{1}{4}$ to $\frac{3}{8}$ inch in length) while the treated trees showed only 2 larvæ below the bands. It was noted,

PLATE VII.



GIPSY MOTH TREE-BANDING MATERIAL

Apple orchard which was badly infested with the gipsy moth; egg clusters were treated by hand and bands applied to trees on right excepting one in right foreground. Note condition of trees not banded, on left.

however, that in the treated trees a greater infestation above the bands was present than in the check lot. It is probable that the larvæ were repelled by the material, consequently they entered the tree above ground. As to the fate of these larvæ that enter the tree above ground, I am not certain. I am of the opinion, however, that many and probably all of them will be killed by winter conditions."

The peach-tree borer is not a pest of first importance in Massachusetts, and the experiments conducted on peach trees by the writers consisted mainly of banding the trees and noting the effect on the bark, the vigor of the trees, and the fruiting. Trees of from 1 to 15 years of age were banded and under observation from 1 to 4 years, and no material injury was noted as a result of the bands.

Observations were also made on a number of species of larvæ found in woodlands where bands were applied. The following species of larvæ were barred or ventured into the bands and were unable to free themselves:

Gipsy moth (*Porthetria dispar* L.).
Brown-tail moth (*Euproctis chrysorrhoea* L.).
White-marked tussock moth (*Hemerocampa leucostigma* S. & A.).
Rusty tussock moth (*Notolophus antiqua* L.).
Forest tent caterpillar (*Malacosoma disstria* Hbn.).
Checkered tussock (*Halisidota tessellaris* S. & A.).
Fall webworm (*Hyphantria cunea* Dru.).
American silkworm (*Telea polyphemus* Cram.).
Fall cankerworm (*Alsophila pometaria* Harr.).
Spring cankerworm (*Paleacrita vernata* Peck.).
Snow-white linden moth (*Ennomos subsignarius* Hbn.).
Ashen pinion (*Xylina antennata* Walk.).

There were also some other species of geometrid, noctuid, tortricid, and tenthredinid larvæ that were barred by these bands.

Some other species were inclosed in trays at the laboratory containing bands of gipsy moth tree-banding material at the top and their behavior observed for a period. The following species were barred, or upon venturing into the bands were unable to free themselves from it:

Salt marsh caterpillar (*Estigmene acraea* Dru.).
Green clover worm (*Plathypena scabra* Fab.).
Red-humped apple caterpillar (*Schizura concinna* S. & A.).
Milkweed butterfly (*Euchaetias egle* Dru.).
Saddled prominent (*Heterocampa guttivitta* Walk.).
Tent caterpillar (*Malacosoma americana* Fab.).

CONCLUSIONS AND RECOMMENDATIONS.

For control of the gipsy moth and several other species of tree-foliage-feeding caterpillars with similar habits, gipsy moth tree-banding material may be used to great advantage. The cost of making and applying this material is 1.08 to 1.42 cents per linear foot (depending upon the width of bands used) whereas the sticky compounds on the market cost 2.56 cents per linear foot. An additional feature is that bands of this material may be retouched or resurfaced and kept in working condition each year with very small cost. Its efficiency in barring caterpillars also compares favorably with the sticky material.

If small apple orchards are to be protected where there is a severe infestation of the gipsy moth and where it is impossible to have such orchards sprayed at the proper time, the egg clusters may be treated by hand and gipsy moth tree-banding material applied economically and with good results.

Injury to the bark of trees is negligible and in no case has there been any more injury noted than with the best banding materials now on the market. It is not advisable, however, to band very young fruit trees directly, as a slight thickening of the bark takes place at that point, which does not add to the beauty of the tree; furthermore insect attacks on trees of this size can be handled more advantageously by spraying.

The width of the band to be used against tree-climbing caterpillars can only be determined by the degree of infestation but it is usually not practicable to apply a band of smaller dimensions than $\frac{13}{16}$ by $\frac{7}{32}$ inch in order that sufficient material be used so that the bands will not dry out too quickly. Bands of these dimensions were found to be the most economical and practical in the extermination work against the gipsy moth in the border territory and are recommended where caterpillar infestations are light or of a medium degree. Double bands of the above dimensions or broader bands, $1\frac{1}{4}$ inches wide or more, will be necessary only when the infestation is extremely heavy. The bands are economically and conveniently applied by the use of a pressure gun made for the purpose.

Caterpillars are barred by gipsy moth tree-banding material when the latter is in good condition, making it a physical impossibility for them to cross. The softness and greasiness of the material are such that large proportions of small larvæ venturing into it become entangled, embedded, or so smeared with oil that death results.

Observations have been made on some insects other than the gipsy moth against which this material might be effective, and it is probable that its use should give equal protection against some of them.

If an organization for insect control work should require large quantities of this material annually, it should equip itself with apparatus for making same. On the other hand, for the owner of a few apple and shade trees it would not be so profitable to make the material on a small scale, although it can be readily done.